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EXAMINER	
SHAW, ROBERT A	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/736,748	LIU ET AL.	
	Examiner	Art Unit	
	ROBERT SHAW	2455	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *16 June 2006*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-18* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-18* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *17 December 2003* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *12/17/2003*.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

DETAILED ACTION

1. This office action is in response to communications filed 6/16/2006. Claims 1- 18 have been examined and are pending.

Claim Objections

2. Claims 17 and 18 are objected to because of the following informalities: The claims are identical. Appropriate correction is required.

3. Claims 17 and 18 recite "maximally aggregating gain of information about the target along the path finding a path that includes determining detours...". The claim is missing a correlative conjunction between "along the path" and "finding a path" and is thus unclear. Appropriate correction is required.

Claim Rejections - 35 USC § 112

4. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

5. Claims 1-9, 13, 14, 16 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

6. Claims 1, 4, and 8 recite "selecting the node with the highest utility to be the destination node". The term "highest utility" is not defined by the claim, the specification

does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the claim. Accordingly it is also unclear how the selection process is to be performed.

7. Claim 1 recites “establishing a leader node”. Neither the specification nor the claim itself defines what constitutes being a leader node or how a leader node is established, and thus the claim is indefinite.

8. Claims 2 and 4 recite the limitation “the selected path” in the clause “selecting a first node in the selected path”. There is insufficient antecedent basis for this limitation in the claims.

9. Claims 3 and 5 recite “adding a very large positive value to the cost of all links of each path”. The term "very large" is a relative term which renders the claim indefinite. The term "very large" is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the claims.

10. Claim 4 recites “a processing mechanism that determines a minimum number of hops required to reach the destination node from a current leader node”. Neither the specification nor the claim itself defines what comprises "a current leader node" .

11. Claim 4 recites the limitation “the m-hop path” in "a path selection mechanism that *selects* the m-hop path that traverses the nodes the sum of whose utilities is the greatest”. There is insufficient antecedent basis for this limitation in the claim.

12. Claim 5 recites “the selection mechanism” of Claim 4, “wherein the selection mechanism comprises: a mechanism adds a very large positive value to the cost of all links of each path”. It is unclear to which of the three selection mechanisms recited in Claim 4 “the selection mechanism” refers.

13. Claim 6 recites “a leadership transfer mechanism that changes leadership from one node to another node”. Neither the specification nor the claim itself defines what comprises “leadership”.

14. Claim 6 recites “a leadership transfer mechanism that changes leadership from one node to another node”. Absent any functional description of this mechanism, or under what conditions leadership is transferred, the claim is indefinite.

15. Claims 7 and 9 recite “determining costs associated with communication that has already occurred along paths to neighborhood sensor nodes”. Neither the specification nor the claims disclose what comprises the “cost associated with communication”, nor from what source or in what context the communication to neighborhood sensor nodes “has already occurred” which would enable determination of the costs.

16. Claims 7 and 9 recite “determining information gain based on neighborhood network sensor nodes already visited for a number of paths...” Neither the specification nor the claimd disclose what comprises the “information gain based on neighborhood network sensor nodes”, nor from what source or in what context the communication to neighborhood sensor nodes “has already occurred” which would enable determination of the information gain.

17. Claim 7 recites “establishing a neighborhood around the source sensor node” Neither the specification nor the claim itself discloses how a neighborhood is “established” nor how the source sensor node is determined.

18. Claim 7 provides for the use of “an RTA* type forward search”, but, since the claim does not set forth any steps involved in the method/process, it is unclear what method/process applicant is intending to encompass. A claim is indefinite where it merely recites a use without any active, positive steps delimiting how this use is actually practiced.

19. Claim 7 recites “conducting an RTA* type forward search to relay from the entry point to the destination point based on the determined cost and information gain”. The claim does not disclose the object of the "relay" action, nor what relationship "the determined cost and information gain" bears to the search and/or relay action(s) such

that "the determined cost and information gain" form the basis for the search and/or relay action(s).

20. Claim 9 recites “determining a source sensor node”. Neither the specification nor the claim itself defines on what basis a source sensor node is determined.

21. Claim 9 recites the limitation “the determined communication costs” in the clause “forming a belief state about the event location based on the determined communication costs and determined information gain” . There is insufficient antecedent basis for this limitation in the claim.

22. Claim 9 recites "forming a belief state about the event location based on the determined communication costs and determined information gain” Neither the specification nor the claim itself defines what comprises a “belief state”, nor wherein it is determined that the event location is "of interest" (per claim preamble).

23. Claim 13 recites “determining a path that is relatively efficient in terms of communication cost”. The term "relatively efficient" is a relative term which renders the claim indefinite. The term "relatively efficient" is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the claim.

24. Claim 14 recites “maximally aggregating information about the phenomenon of interest along [a] path”. Neither the specification nor the claim itself provides the basis for determining what comprises “the phenomenon of interest”.

25. Claim 14 recites the limitation “the destination node” in the phrase “estimating the information expected to be gained from the entry node to the destination node”. There is insufficient antecedent basis for this limitation in the claim.

26. Claim 14 recites “estimating the information expected to be gained from the entry node to the destination node”. Neither the specification nor the claim itself provides the basis for performing this estimation.

27. Claim 16 recites the limitation “target estimates” in the phrase “obtaining network node sensor measurements to refine target estimates.” There is insufficient antecedent basis for this limitation in the claim.

28. Claim 16 recites “refin[ing] target estimates” Neither the specification nor the claim itself provides the basis for determining what comprises "refine[ment]” of target estimates.

Claim Rejections - 35 USC § 103

29. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

30. Claims 1, 3, 13, 14 -16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hsu (US Patent 6,363, 319) in view of Hintz et al (US Patent 6,801,878)

31. Hsu teaches the invention substantially as claimed including selection of an optimum routing path in a network calculated on the basis of joint optimization (see Abstract)

32. Regarding Claim 1, Hsu teaches method of routing one or more information query from one or more arbitrary sensor network entry points in a network of sensor nodes to one or more destination nodes in the vicinity of physical phenomena of interest in the network, comprising:

establishing a leader node (Step 410 of Fig. 4, as further detailed in Fig. 5 showing initial vertex assignment of spanning tree (Step 530 of Fig. 5));

using a multiple step lookup procedure to determine an optimum path (having minimum cost bias) between the leader node and the destination node (col. 7/ lines 1-

34 describing performance of the optimum path calculation; Steps 420 - 460 of Fig. 4, illustrating multi-step selection of nodes using biased cost in order to determine optimum path; Figs. 6,7 showing selection of optimum path); and

routing data to a destination node based on the determined optimum path (Abstract, routing according to optimum path calculation is performed for data flows).

Hsu does not teach:

selecting a destination node by computing the utility of a plurality of network sensor nodes and selecting the node with the highest utility to be the destination node

wherein routing to a destination node based on the determined optimum path is performed with respect to an information query in a sensor network.

Hintz teaches:

selecting a destination node by computing the utility (expected information gain) of a plurality of network sensor nodes and selecting the node with the highest utility to be the destination node (col 8/lines 55-64; Sensor Scheduler determines where to retrieve data based on supplied constraints; col 2/lines 12-14, "expected information gain has been shown to be a useful approach to sensor management when used primarily to trade-off the functions of search, track, and identify")

wherein routing to a destination node based on the determined cost and aggregated information gain is performed with respect to an information query in a sensor network (Abstract, the invention is directed at a sensor management system, including identifying destination is based on "information needs")

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Hintz regarding selection of a destination based on expected information gain with the teachings of Hsu regarding optimal path calculation and routing.

One would be motivated to do so in order to achieve maximum utility for routing from a given source to the selected destination based on an information query in a sensor network.

33. Regarding Claim 3 Hsu teaches the method Claim 1 above, wherein finding the min-hop path between a source and a destination comprises:

adding a very large positive value to the cost of all links of each path. (col 7/ lines 10-14, col 9/lines 3-10 Referring to Step 410 of Fig. 4, as further detailed in Fig. 5; setting biased cost = infinity for all but the source vertex)

34. Regarding Claim 13, Hsu teaches a method of information-directed query routing along a path from a source node to a destination node in a network of sensor nodes, comprising:

determining a path that is relatively efficient in terms of communication cost(col. 7/ lines 1-34 describing performance of the optimum path calculation, including especially Step2 regarding cost factor c(v,w); Fig. 4 including Step 430 as further detailed in Fig 6 including cost factor c(v,w) used in conjunction with bias factor to determine optimum path);

maximally aggregating gain of information about the event along the path (col 7/line 5, L(x)=cumulative biased cost from source S to vertex x; col 7/lines 15-23, setting of L(w) in Step 2; Fig. 4 including Step 430 as further detailed in Fig 6 showing L(x) in the route calculation)

and routing the query based on the determined cost and aggregated information gain (Abstract, routing according to optimum path calculation is performed for data flows).

Hsu does not teach:

wherein routing to a destination node based on the determined cost and aggregated information gain is performed with respect to an information query in a sensor network

Hintz teaches:

wherein routing to a destination node based on the determined cost and aggregated information gain is performed with respect to an information query in a sensor network (Abstract, identifying destination is based on "information needs"; col 2/lines 12-14, “expected information gain has been shown to be a useful approach to sensor management when used primarily to trade-off the functions of search, track, and identify”)

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Hintz regarding selection of a destination based on expected information gain with the teachings of Hsu regarding optimal path calculation and routing.

One would be motivated to do so in order to achieve maximum utility with respect to information gain vs. cost constraints for routing from a given source to the selected destination for an information query in a sensor network.

35. Regarding Claim 14, Hsu teaches as method of point-to-point routing of query information regarding a phenomenon of interest in a sensor network having a plurality of sensor nodes along a path from an arbitrary entry point node to an arbitrary exit point node, comprising:

establishing a leader node (Step 410 of Fig. 4, as further detailed in Fig. 5 showing initial vertex assignment of spanning tree (Step 530 of Fig. 5));

maximally aggregating gain of information about the event along the path (col 7/line 5, L(x)=cumulative biased cost from source S to vertex x; col 7/lines 15-23, setting of L(w) in Step 2; Fig. 4 including Step 430 as further detailed in Fig 6 showing L(x) in the route calculation)

selecting a successor leader node based on the estimated information expected to be gained (Step 450-460 of Fig. 4, determining vertex v with biased cost w_{min} , and setting v = w_{min} ; where path computation is based on vertex v);

and routing the query based on the determined cost and aggregated information gain (Abstract, routing according to optimum path calculation is performed for data flows).

<u>Hsu does not teach</u>:

wherein selecting a successor leader node, and routing to a destination node based on the maximally aggregated information gain is performed with respect to an information query in a sensor network

Hintz teaches:

wherein selecting a successor leader, routing to a destination node based on the aggregated information gain is performed with respect to an information query in a sensor network (Abstract, identifying destination is based on "information needs"; col 2/lines 12-14, “expected information gain has been shown to be a useful approach to sensor management when used primarily to trade-off the functions of search, track, and identify”)

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Hintz regarding use of information gain in a sensor network with the teachings of Hsu regarding optimal path calculation and routing.

One would be motivated to do so in order to achieve maximum utility with respect to information gain vs. cost constraints for routing from a given source to the selected destination for an information query in a sensor network.

36. Regarding Claim 15 Hsu teaches the method of claim 14, wherein

estimating the information expected comprises establishing moving a frontier (Step 450-460 of Fig. 4, setting vertex v with biased cost w_{min}, and setting v = w_{min}; where path computation is based on vertex v) and

iteratively expanding the nodes on the frontier until the exit point node is reached (col. 7/ lines 1-34 describing performance of the optimum path calculation using iterative process based on current vertex v)

37. Regarding Claim 16, Hsu teaches the method of Claim 14 above, including routing based on maximally aggregated information.

Hsu does not teach:

wherein the arbitrary exit point is the location of an event of interest and further comprising: obtaining network node sensor measurements to refine target estimates.

Hintz teaches:

wherein the arbitrary exit point is the location of an event of interest (Fig 3, Mission Manager sends Information Request based on Mission Goals/Objectives (i.e. event of interest) to Information Instantiator which translates into Observation Request for Sensor Scheduler; col 8/lines 55-64; Sensor Scheduler determines where to retrieve data based on supplied constraints)

and further comprising:

obtaining network node sensor measurements to refine target estimates (col. 9/lines 32-37, “The amount of maneuverability of a target has a direct correlation to the amount of uncertainty about the target's future position. One can either increase the measurement rate of a sensor or combine independent measurements from multiple sensors in order to decrease uncertainty or, equivalently, to gain information.”)

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Hintz regarding use of information gain in a sensor network with the teachings of Hsu regarding optimal path calculation and routing.

One would be motivated to do so in order to achieve maximum utility with respect to information gain for routing from a given source to the selected destination for an information query in a sensor network.

38. Claims 17 and 18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hsu and Hintz in view of A. Stentz, *Optimal and Efficient Path Planning for Partially-Known Environments*, Conference Proceedings on Robotics and Automation, vol. 4, IEEE International, May 1994 (hereafter Stentz)

39. Hsu teaches the invention substantially as claimed including selection of an optimum routing path in a network calculated on the basis of joint optimization (see Abstract)

40. Regarding Claims 17 and 18, Hsu teaches the method of Claim 13 above, including aggregating gain of information along a path.

<u>Hsu and Hintz do not teach</u>:

finding a path that includes determining detours around sensor network holes and at least one path ending

<u>Stentz teaches</u>:

finding a path that includes determining detours around sensor network holes (obstacles) and at least one path ending (p. 3310, §1.0, "One approach to path planning in this scenario is to generate a "global" path using the known information and then ..."locally" circumvent obstacles on the route detected by the sensors... It is possible to generate optimal behavior by computing an optimal path from the known map information, moving ... along the path until either [one] reaches the goal or ... sensors detect a discrepancy between the map and the environment, updating the map, and then replanning a new optimal path from the .. current location to the goal"; p. 3313, §2.3 Illustrating operation of D* algorithm to provide detours around obstacles, by setting arc costs "prohibitively large" for obstacle cells)

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Stentz regarding obstacle avoidance with the teachings of Hsu and Hintz regarding optimal path calculation and routing in a sensor network environment.

One would be motivated to do so since a path that includes sensor network holes ("total obstacles") will not reach the destination.

41. Claim 2, 4-8, and 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hsu and Hintz in view of S. Edelkamp and J. Eckerle, *New Strategies in Learning Real Time Heuristic Search*, AAAI Technical Report WS-97-10, 1997, p.30-35 (hereafter Edelkamp)

42. Hsu teaches the invention substantially as claimed including selection of an optimum routing path in a network calculated on the basis of joint optimization(see Abstract)

43. Regarding Claim 2, Hsu teaches the method of claim 1 above, wherein the multiple step lookup procedure comprises:

determining a minimum number of hops(shortest-hop path) required to reach the destination node from the leader node (col 5 /lines 44-45, 49-55Associated with each link (v,w) is a cost metric c(v,w). Using Dijkstra's algorithm and assigning each link a cost of 1, the least-cost path to the destination is the shortest-hop path) ;

selecting a minimum number of hops path that traverses the nodes the sum of whose utilities is the greatest (lowest cost bias) and (col. 7/ lines 1-34 describing performance of the optimum path calculation; Steps 420 - 460 of Fig. 4, illustrating multi-step selection of nodes using biased cost in order to determine optimum path; Figs. 6,7 showing selection of optimum path) and

selecting a first node in the selected path (Step 450 of Fig. 4, determining vertex v with biased cost w_{min}) and

passing leadership from the leader node to the first node (Step 460 of Fig. 4, setting v = w_{min} ; where path computation is based on vertex v).

Hsu and Hintz do not teach:

determining all possible paths of the minimum number of hops or less from the current leader node to the destination node

determining the utilities of all possible minimum number of hops paths

Edelkamp teaches:

determining all possible paths of the minimum number of hops or less from the current leader node to the destination node (shortest path values); [and] determining the utilities of all possible minimum number of hops paths; (p.31 col.1, "The distance of one node to the set of goal nodes F is the minimum of the shortest path values for all g ϵ F. The most efficient approach … to find all shortest path values to set F is to put all goal nodes [(collection of shortest path values)] in the priority queue at once and to calculate the distances f to the set F dynamically");

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Edelkamp regarding generating a collection of minimum path values and selecting the optimal path from amongst the collection, with those of Hsu regarding path generation based on reachability of the destination and use of a utility weighting function for path selection.

One would be motivated to do so since the combination provides an efficient mechanism for determining an optimum path based on utility and reachability of the destination.

44. Regarding Claim 4, Hsu teaches a system to route information via a network of sensor nodes from a leader node to a destination node, comprising:

a processing mechanism that determines a minimum number of hops required to reach the destination node from a current leader node (col 5 /lines 44-45, 49-55;

Associated with each link (v,w) is a cost metric c(v,w). Using Dijkstra's algorithm and assigning each link a cost of 1, the least-cost path to the destination is the shortest-hop path);

a path selection mechanism that selects the m-hop path that traverses the nodes the sum of whose utilities is the greatest (col. 7/ lines 1-34 describing performance of the optimum path calculation; Steps 420 - 460 of Fig. 4, illustrating multi-step selection of nodes using biased cost in order to determine optimum path; Figs. 6,7 showing selection of optimum path); and

a selection mechanism that selects a first node in the selected path (Step 450 of Fig. 4, determining vertex v with biased cost w_{min}) and

passes leadership from the leader node to the first node (Step 460 of Fig. 4, setting v = w_{min} ; path computation based on vertex v).

<u>Hsu does not teach</u>:

a destination node selection mechanism, that determines the utility of a plurality of nodes and selects a node with the highest utility to be the destination node

<u>Hintz teaches</u>:

a destination node selection mechanism, that determines the utility of a plurality of nodes and selects a node with the highest utility to be the destination node (col 8/lines 55-64; Sensor Scheduler determines where to retrieve data based on supplied constraints; col 2/lines 12-14, “expected information gain has been shown to be a useful approach to sensor management when used primarily to trade-off the functions of search, track, and identify”)

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Hintz regarding selection of a destination based on expected information gain with the teachings of Hsu regarding optimal path calculation and routing.

One would be motivated to do so in order to achieve maximum utility for routing from a given source to the selected destination.

Hsu and Hintz do not teach:

a processing mechanism that determines a minimum number of hops required to reach the destination node from a current leader node;

a processing mechanism that determines a number of possible paths within a specified number of hops or less from the current leader node to the destination node;

Edelkamp teaches:

a processing mechanism that determines a minimum number of hops required to reach the destination node from a current leader node; [and] a processing mechanism that determines a number of possible paths within a specified number of hops or less from the current leader node to the destination node (p.31 col.1, "The distance of one node to the set of goal nodes F is the minimum of the shortest path values for all g ϵ F. The most efficient approach … to find all shortest path values to set F is to put all goal nodes [(collection of shortest path values)] in the priority queue at once and to calculate the distances f to the set F dynamically")

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Edelkamp regarding generating a collection of

minimum path values and selecting the optimal path from amongst the collection, with those of Hsu regarding path generation based on reachability of the destination and use of a utility weighting function for path selection, and those of Hintz regarding selection of a destination based on expected information gain.

One would be motivated to do so since the combination provides an efficient mechanism for determining an optimum path from a source to a selected destination which provides for maximum utility.

45. Regarding 5, Hsu teaches the system of claim 4, wherein the selection mechanism comprises:

a mechanism adds a very large positive value to the cost of all links of each path (col 7 lines 10-14, col 9/lines 3-10 Referring to Step 410 of Fig. 4, as further detailed in Fig. 5; setting biased cost = infinity for all but the source vertex); and

a mechanism that runs a shortest path algorithm to determine the best among the minimum hop paths from the leader node to the destination node (col 6/lines 39-41, "the biased cost route selection technique leaves the [underlying] hop-by-hop routing system intact"; col 6/lines 58-61, "The biased cost route selector [simply] modifies the ... algorithm by replacing the static cost c(v, w)used in the Dijkstra [(shortest path)] process by a biased cost....")

46. Regarding Claim 6, Hsu teaches the system of claim 4, further comprising

a leadership transfer mechanism that changes leadership from one node to another node (Step 460 of Fig. 4, setting $v = w_{min}$; path computation based on vertex v)

47. Regarding Claim 7, Hsu teaches a point-to-point query routing method via a network of sensor nodes including a source sensor node and a destination sensor node, comprising:

establishing a neighborhood around the source node; (col 7/line 3-4; “S=the set of candidate vertices to be added to the spanning tree”; col 7/lines 30-32, "Find the vertex w in S with the minimum L(w). Add w to the spanning tree and set v=w. This will be the vertex whose neighbors will be examined in the next iteration.”)

determining costs associated with communication that has already occurred along paths to neighborhood sensor nodes and costs associated with going forward along paths to sensor nodes in the neighborhood of the source node (col 7/lines 1- 34, describing performance of the biased cost route selection; Fig. 4, including Step 430 as further detailed in Fig 6 showing cost factor c(v,w) in the calculation);

determining information gain based on neighborhood network nodes already visited for a number of paths and to be visited for a number of paths (col. 7/ lines 1-34 describing performance of the optimum path calculation; Fig. 4, including Step 430 as further detailed in Fig 6 showing bias factor in the calculation);

<u>Hsu does not teach</u>:

wherein establishing a neighborhood, determining costs and routing to a destination node are performed with respect to an information query in a sensor network

Hintz teaches:

wherein establishing a neighborhood, determining costs and routing to a destination node based on the determined cost and aggregated information gain is performed with respect to an information query in a sensor network (Abstract, the invention is directed at a sensor management system, including identifying destination is based on "information needs"; col 2/lines 12-14, “expected information gain has been shown to be a useful approach to sensor management when used primarily to trade-off the functions of search, track, and identify”)

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Hintz regarding selection of a destination based on expected information gain with the teachings of Hsu regarding optimal path calculation and routing.

One would be motivated to do so in order to achieve maximum utility with respect to information gain vs. cost constraints for routing from a given source to the selected destination for an information query in a sensor network.

Hsu and Hintz do not teach:

conducting an RTA* type forward search to relay from the entry point to the destination point based on the determined cost and information gain.

Edelkamp teaches:

conducting an RTA* type forward search to relay from the entry point to the destination point based on the determined cost and information gain (p. 32 The algorithm *SRTA** (real-time A* using signs) is similar to the *RTA** procedure where

"improvement is based on signs that are assigned to each edge in the state space. Each sign is seen as a lower bound for the shortest path passing this edge")

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Edelkamp with regard to use of an RTA* type heuristic forward search with the teachings of Hsu and Hintz regarding computing an optimal route from a given source to the selected destination for an information query in a sensor network.

One would have been motivated to do so since RTA* is a well-known search algorithm for use in real-time systems such as a sensor environment.

48. Regarding Claim 8, Hsu teaches a method of routing information about the location of an event via a network of sensor nodes including a leader node and a destination node, comprising:

selecting a path that traverses the nodes the sum of whose utilities is the greatest (col. 7/ lines 1-32 describing optimum path determination; Steps 420 - 460 of Fig. 4, illustrating multi-step selection of nodes using biased cost in order to determine optimum path; Figs. 6,7 showing selection of optimum path) and

selecting a first node in the selected path)(Step 450 of Fig. 4, determining vertex v with biased cost w_{min}) and

passing leadership from the leader node to the first node (Step 460 of Fig. 4, setting v = w_{min} ; path computation based on vertex v).

<u>Hsu does not teach</u>:

selecting a destination location by computing the utility of a plurality of nodes and selecting a node with the highest utility to be the destination node

determining a minimum number of hops required to reach the destination location from a current leader node

Hintz teaches:

selecting a destination node by computing the utility (expected information gain) of a plurality of network sensor nodes and selecting the node with the highest utility to be the destination node (col 8/lines 55-64; Sensor Scheduler determines where to retrieve data based on supplied constraints; col 2/lines 12-14, "expected information gain has been shown to be a useful approach to sensor management when used primarily to trade-off the functions of search, track, and identify")

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Hintz regarding selection of a destination based on expected information gain with the teachings of Hsu regarding optimal path calculation and routing.

One would be motivated to do so in order to achieve maximum utility for routing from a given source to the selected destination.

Hsu and Hintz do not teach:

determining a minimum number of hops required to reach the destination location from a current leader node;

determining all possible paths within a specified number of hops or less from the leader node to the destination node;

Edelkamp teaches:

determining a minimum number of hops required to reach the destination location from a current leader node; [and] determining all possible paths within a specified number of hops or less from the leader node to the destination node (p.31 col.1, “The distance of one node to the set of goal nodes F is the minimum of the shortest path values for all g ϵ F. The most efficient approach … to find all shortest path values to set F is to put all goal nodes [(collection of shortest path values)] in the priority queue at once and to calculate the distances f to the set F dynamically")

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Edelkamp regarding generating a collection of minimum path values and selecting the optimal path from amongst the collection, with those of Hsu regarding path generation based on reachability of the destination and use of a utility weighting function for path selection, and those of Hintz regarding selection of a destination based on expected information gain.

One would be motivated to do so since the combination provides an efficient mechanism for determining an optimum path from a source to a selected destination which provides for maximum utility.

49. Regarding Claim 10, Hsu teaches the system of claim 4, including constraint-based routing of information within a network (see Abstract)

Hsu does not teach:

a network of sensor nodes ... wherein the sensor nodes comprise different types of sensors.

Hintz teaches:

a network of sensor nodes ... wherein the sensor nodes comprise different types of sensors. (col 1/lines 12-13, 28-30; col 2/line 33, The system is directed towards managing sensors “in a heterogeneous multisensor system”)

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Hintz with regard to managing a network of heterogeneous sensor nodes to those of Hsu regarding constraint based routing.

One would have been motivated to do so in order to route information requests to a selected sensor in the network (Hintz: col 8/lines 55-64; Sensor Scheduler determines where to retrieve data based on supplied constraints)

50. Claim 9 is rejected under 35 U.S.C. 103(a) as being unpatentable over Hsu and Hintz in view of D. Blei and L. Kaelbling, Shortest Paths in a Dynamic Uncertain Domain, Proceedings of the IJCAI Workshop on Adaptive Spatial Representation of Dynamic Environments, 1999 (hereafter Blei)

51. Regarding Claim 9 Hsu teaches a method of routing a query about the location of an event of interest via a network of sensor nodes, comprising:

determining a source node(Step 410 of Fig. 4, as further detailed in Fig. 5 showing initial vertex assignment of spanning tree (Step 530 of Fig. 5));

establishing a neighborhood around the source node (col 7/line 3-4; “S=the set of candidate vertices to be added to the spanning tree”; col 7/lines 30-32, "Find the vertex w in S with the minimum L(w). Add w to the spanning tree and set v=w. This will be the vertex whose neighbors will be examined in the next iteration.”);

determining costs associated with communication that has already occurred along paths to neighborhood nodes and costs associated with going forward along paths to neighborhood nodes (col 7/lines 1- 34, describing performance of the biased cost route selection; Fig. 4, including Step 430 as further detailed in Fig 6 showing cost factor c(v,w) in the calculation);

determining information gain based on neighborhood network sensor nodes already visited for a number of paths and to be visited for a number of paths (col. 7/ lines 1-34 describing performance of the optimum path calculation; Fig. 4, including Step 430 as further detailed in Fig 6 showing bias factor in the calculation);

Hsu does not teach:

wherein determining a source node; establishing a neighborhood around the source node; determining associated communication costs/information gain relative to neighborhood nodes; and routing to a destination node are performed with respect to an information query in a sensor node network

Hintz teaches:

wherein establishing a neighborhood, determining costs and routing to a destination node based on the determined cost and aggregated information gain is performed with respect to an information query in a sensor network (Abstract, the

invention is directed at a sensor management system, including identifying destination is based on "information needs"; col 2/lines 12-14, “expected information gain has been shown to be a useful approach to sensor management when used primarily to trade-off the functions of search, track, and identify”)

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Hintz regarding selection of a destination based on expected information gain with the teachings of Hsu regarding optimal path calculation and routing.

One would be motivated to do so in order to achieve maximum utility with respect to information gain vs. cost constraints for routing from a given source to the selected destination for an information query in a sensor network.

<u>Hsu and Hintz do not teach</u>:

forming a belief state about the event location based on the determined communication costs and determined information gain

<u>Blei teaches</u>:

forming a belief state about the event location (“goal”) based on the determined communication costs and determined information gain (§2.2 Analysis: “[T]he optimal policy takes into account both the value of gaining information about uncertain [links] and the value of moving closer to the goal [(i.e. a movement once made incurs cost)]”)

and routing the query based on the belief state (§3.1 “A POMPD [(Partially Observable Markov Decision Process)] is a model in which the agent is not sure of its state but makes observations as it acts in the world … To act optimally in a POMPD the

agent needs to select its action based its history of observations and actions … Finding optimal policy in a POMP amounts to solving a continuous mdp [(Markov Decision Process)] where the state is a belief state a probability distribution over S (where S is a finite set of states)"; §5, the model may be used in network packet routing)

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52. Claims 11-12 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hsu, Hintz, and Edelkamp in view of Gelvin et al. (US Patent 6859831)

53. Hsu teaches the invention substantially as claimed including selection of an optimum routing path in a network calculated on the basis of joint optimization (see Abstract)

54. Regarding Claim 11, Hsu teaches the system of claim 4, including constraint-based routing of information within a network (see Abstract)

<u>Hsu and Hintz do not teach</u>:

a network of sensor nodes … wherein the sensor nodes comprise acoustic sensors

<u>Gelvin teaches</u>:

a network of sensor nodes … wherein the sensor nodes comprise acoustic sensors (col 18/lines 37-44; The "sensors include seismic, acoustic, and infrared motion devices".)

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Gelvin regarding use of a particular sensor with those Hintz with regard to managing a network of heterogeneous sensor nodes (col 1/lines 12-13, 28-30; col 2/line 33, The system is directed towards managing sensors "in a heterogeneous multisensor system") and those of Hsu regarding constraint based routing.

One would have been motivated to do so in order to route information requests to a selected sensor of the appropriate type in the network (Hintz: col 8/lines 55-64; Sensor Scheduler determines where to retrieve data based on supplied constraints)

55. Regarding Claim 12, Hsu teaches the system of claim 4, including constraint-based routing of information within a network (see Abstract)

Hsu and Hintz do not teach:

a network of sensor nodes ... wherein the sensor nodes comprise seismic sensors

Gelvin teaches:

a network of sensor nodes ... wherein the sensor nodes comprise seismic sensors (col 18/lines 37-44; The "sensors include seismic, acoustic, and infrared motion devices".)

It would have been obvious for one of ordinary skill in the art at the time of the invention to apply the teachings of Gelvin regarding use of a particular sensor with those Hintz with regard to managing a network of heterogeneous sensor nodes (col

1/lines 12-13, 28-30; col 2/line 33, The system is directed towards managing sensors “in a heterogeneous multisensor system”) and those of Hsu regarding constraint based routing.

One would have been motivated to do so in order to route information requests to a selected sensor of the appropriate type in the network (Hintz: col 8/lines 55-64; Sensor Scheduler determines where to retrieve data based on supplied constraints)

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ROBERT SHAW whose telephone number is (571) 270-5643. The examiner can normally be reached on 8:30am- 5:30pm Monday-Thursday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner’s supervisor, Saleh Najjar can be reached on (571) 272-4006. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/R. S./
Examiner of Art Unit 2455

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Supervisory Patent Examiner, Art Unit 2455